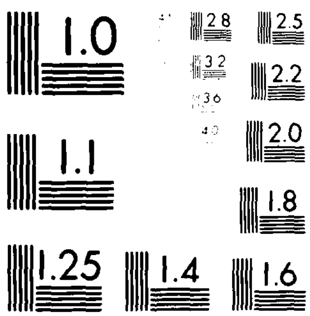
AD-A088 157 FEDERAL AVIATION ADMINISTRATION WASHINGTON DC OFFICE --ETC F/G 1/5
DESCRIPTION OF THE MULTIPLE AIRPORT DEMAND ALLOCATION MODEL,(U)
SEP 77 B CAMPBELL, W R FROMME
UNCLASSIFIED FAA-AVP-77-39 NL

1 OF 1
AD
A088157

END
DATE
FILMED
9-80
DTIC



MICROCOPY RESOLUTION TEST CHART

(14)

REPORT NO. FAA-AVP-77-39

LEVEL

AD A088157

DESCRIPTION OF THE MULTIPLE AIRPORT DEMAND ALLOCATION MODEL

(10) E./Campbell

William R./Fromme

DTIC
ELECTE
AUG 20 1980
S D
C

September, 1977

Technical Supplement to
The Metropolitan Washington Airport Policy Analysis

Prepared for

United States Department of Transportation
Federal Aviation Administration

Office of Aviation Policy
Washington, D.C. 20591

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FAA-AVP-77-39	AD-A088 157	
4. Title and Subtitle MULTIPLE AIRPORT DEMAND ALLOCATION MODEL		5. Report Date SEPTEMBER, 1977 6. Performing Organization Code 8. Performing Organization Report No.
7. Author(s) B. CAMPBELL, TECHNICAL MONITOR W. R. FROMME		
9. Performing Organization Name and Address BRIAN CAMPBELL AND ASSOCIATES 1019 19TH STREET WASHINGTON, D.C		10. Work Unit No. (TRAIS) 11. Contract or Grant No. 13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address OFFICE OF AVIATION POLICY FEDERAL AVIATION ADMINISTRATION WASHINGTON, D.C. 20591		14. Sponsoring Agency Code FAA (AVP 210)

15. Supplementary Notes

NONE

16. Abstract

This report describes a computer model, the Multiple Airport Demand Allocation Model, used by the Federal Aviation Administration (FAA) to determine the relative distribution of air passengers between Washington National, Dulles International, and the Baltimore-Washington International Airports for each of a number of airport policy alternatives which are being considered. This model and the report describing it support the FAA's policy statement for the Metropolitan Washington Airports.

The model is based upon the understanding that choice of airports, when more than one is available, is determined largely by the relative attractiveness of each facility to air travelers. Attractiveness of each airport is influenced by the location of the facility relative to population and business centers; the speed and cost of airport access, the availability of convenient flight schedules; and airport capacity limitations among other things. All of these factors vary over time as population growth, access systems, and airport capacities change.

17. Key Words	18. Distribution Statement
METROPOLITAN WASHINGTON AIRPORTS AIRPORT POLICY ANALYSIS AIRPORT PASSENGER DISTRIBUTION	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED		

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS

Section	Title	Page
I	INTRODUCTION	1
II	THE MULTIPLE AIRPORT DEMAND ALLOCATION MODEL	4
III	INPUT DATA AND ASSUMPTIONS	14
IV	1990 BASELINE RUN	24

INDEX TO TABLES

Table No.	Title
1	Forecast O&D Traffic By External City
2	Forecast Distribution of Local Originations By Local Zone
3	Estimated Ratios of Enplaned and On-Board Traffic to Local O&D Passengers
4	Passenger Departure Preferences By Time of Day
5	Average Local Access Measures - 1990
6	Estimated Hourly Departure Capacities - 1990 Baseline
7	Flight Scheduling Rules - 1990
8	1990 Forecast of Aircraft Operations By Type of Aircraft

SECTION I: INTRODUCTION

Until recently, no satisfactory analytical technique existed for forecasting the distribution of air passenger demand among airports within a multi-airport hub complex. Most master-planning efforts or airport system studies have ignored the dynamics of interaction among multiple airports serving the same area, or were content to make simplistic assumptions as to the number of passengers using each airport. However, the process by which traffic divides among several airports is not subject to simple assumption, particularly in the long run, since the factors that have governed past experience do not remain constant into the future. For example, the relative attractiveness of each airport is influenced by the speed and cost of available access systems, by the geographic location of the airport relative to the distribution of area population and business centers, and by the amount of access and terminal congestion or inconvenience to which a passenger is subjected. All of these factors vary over time, as demographic factors, access systems, and airport capacities change. Some are external to the aviation system (e.g., demographic factors), while others are a function of the type of system being considered (e.g., quality of airline service, terminal congestion). All interest to influence air travelers' choice of airport.

In an effort to analytically simulate these interactions, Simat, Helliesen & Eichner, Inc. (SH&E) has developed a computer model[1/] that projects both traffic volume and flight activity at each airport in a multi-airport situation. The model was originally developed by SH&E in 1971 for the Metropolitan Transportation Authority (MTA) of the State of New York, to be used in formulating a master plan for development of Stewart Airport in Newburgh, New York as the fourth

---

1/ Multiple Airport Demand Allocation Model (MADAM).

New York area jetport. The model was used to project the volume of traffic by local point of origination/termination and the number of fligts by aircraft type and time of day at each airport in the metropolitan area. Since this initial application, SH&E has further developed the model, and applied it to other cities in a number of other airport and aviation system studies, including Atlanta, San Francisco/Oakland and Washington/Baltimore.

However, it should be noted that the model is limited in its application to domestic scheduled air carrier service, which is the major component of traffic and flight activity at most air carrier airports. Other aspects of airport activity (general aviation, charter, international, all-cargo, and military operations) must be assessed independently.

It is also important to note the limitations of this and other computer models. A model is only an analytical tool which permits the researcher to break a highly complex and interactive problem into its component parts, each one often requiring assumptions and forecasts. The parts are then linked together by mathematical relationships, which must be specified by the researcher. Then, with the aid of a computer, complex and detailed analyses may be performed quickly and economically. This permits the testing of a number of competing hypotheses and alternative assumptions at a relatively low cost and in a short period of time. It also makes feasible the periodic updating of results as conditions and assumptions change. However, model results are only as good as the underlying assumptions and relationships which have been determined by the researcher. All results must be carefully tested for reasonableness by knowledgeable people, and must be viewed in the context of the assumptions upon which they are based.

The remaining sections of this workpaper describe the

Multiple Airport Demand Allocation Model (MADAM), its internal working mechanisms, the types of data required, and the sources of data used. Though a number of versions and modifications of the model have been developed, this paper will cover only the version that was applied in this study for the Washington/ Baltimore region in a 1990 time frame.

SECTION II: THE MULTIPLE AIRPORT DEMAND ALLOCATION MODEL

Major Elements of the Model

The complete Multiple Airport Demand Allocation Model contains four major constituent elements or submodels:

Element 1: Calibration of the Demand Estimating Equations

The purpose of calibrating the demand model is mathematically to relate the volume of known demand in an historical period to all of the variables which significantly explain that level and composition of demand.

Element 2: Forecast of Future Demand

Once the demand model is calibrated, forecasts of future demand are calculated by applying the elasticities (if constant) or elasticity functions (if variables), as well as the independently forecast rates of change in the explanatory variables, to the base year known demand.

Element 3: Assignment of Demand to Airports

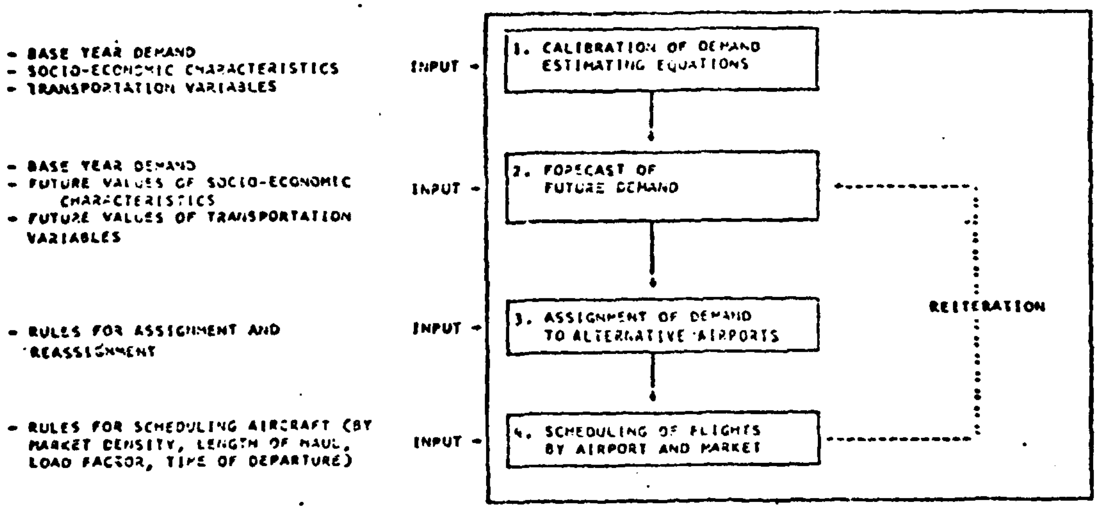
Element 2, above, produces demand estimates for future air travel over a network of routes in and out of the region. The third step is to assign passengers to one of the alternative Washington/Baltimore airports. This requires rules of assignment and reassignment, which are fully discussed in a later section of this workpaper.

Element 4: Scheduling of Flights

The fourth major element is the scheduling of flights on a market-by-market basis for each of the alternative airports. This requires a complex set of rules, which are described later in this workpaper.

Since both demand and frequency of flights are interactive elements, the model may reiterate through Elements 2, 3 and 4 until very little change in total regional demand is produced.

MAJOR ELEMENTS OF THE MULTIPLE AIRPORT DEMAND ALLOCATION MODEL



In this study, however, only Elements 3 and 4 of the model were applied. The forecast of 1990 regional passenger demand was adapted from the current official forecasts of the FAA. Consequently, the model was only used to allocate forecast passenger volumes among alternative airports in the Washington/Baltimore area, and to project schedules at each airport by market, by aircraft type, and by the time of the day.

Allocation of Demand to Alternative Airports and Scheduling of Aircraft Operations

The primary objective of the model is to reflect a realistic balance between passenger preferences and airline scheduling practices under conditions of constrained supply factors. While the whole analytical process is iterative, the model does not attempt to provide an economically "optimum" solution

for any single party to the multi-airport problem, but rather attempts to satisfy multiple considerations, even though some may be in competition with others. Each major step in the model, as it is applied in this study, is described below:

Step 1: Initial Allocation of Traffic to Airports

The analytical procedure begins with the matrix of roundtrip demand from each local zone to each external city, converted to a daily average demand.1/ The forecast traffic from each local zone is first assigned to one of the competing airports based only on minimum total travel time. That is, each passenger is initially assigned to the airport which would result in the shortest door-to-door roundtrip from local origination to external city and back.2/ The exception to this rule is that passengers travelling to cities to which service is not permitted from particular airports3/ may be assigned only to those airports from which service is allowed. (For example, Los Angeles traffic could not be assigned to Washington National).

Step 2: Generation of Initial Flight Schedules

After the traffic from each local zone is assigned to an airport, aircraft departures from each of the airports in the

---

1/ In this study, the Washington-Baltimore area was divided into 72 local zones, and the remainder of Maryland and Virginia and other neighboring states generating local air traffic comprised 6 additional zones. A total of 67 external cities, having or projected to have nonstop service from area airports, were included in the study. This matrix of markets was adapted from the current study of the Metropolitan Washington Council of Governments (COG).

2/ The model has the capability of including competing modes of transportation with their own terminals, travel times, etc., although this feature was not used in this study.

3/ Service limitations in this study include the perimeter rule at National.

region are scheduled by destination, by aircraft type, and by time of day.[1/]

The scheduling procedure is designed to translate passenger demand, at each airport, into aircraft movements. The objective of the procedure is not to optimize the schedules of the airlines in terms of revenues, load factors, or profits, not to minimize peaking, congestion, or operating costs, but to reflect actual scheduling practices of the airlines as closely as possible. The procedure has to be empirical in order to realistically determine gate and runway requirements during peak hours. It is therefore descriptive rather than prescriptive.

The procedure must also reflect conditions which have not existed in the past, but which are likely to have a significant impact in the future. For example, it has to allow for the widespread use of DC-10's and L-1011's and also for a twin-engine widebodied jet of the A-300B type or Boeing 7X7 by the year 1990. It also must consider the imposition of load factor standards by the Civil Aeronautics Board and the high price of fuel, both of which have modified the scheduling behavior of the domestic airlines so that the historical long-term trends toward lower load factors have been reversed. Finally, the scheduling procedure must reflect the unique nature of each city's role in the air transportation system, as reflected in its volume of through and connecting traffic, and in the nature and timing of its aircraft movements.

The empirical method which most clearly met the requirements of the model was that developed by the Air Transport Association of America, with the assistance of scheduling,

---

1/ The model schedules only departing flights. For analytical purposes, arriving flights are assumed to correspond in frequency, type of equipment, load factor, passenger volume, etc.

traffic, economic and executive personnel of all the domestic airlines.[1/] The method developed by the ATA required modification to handle the trends towards larger jets and higher load factors.

The method as modified assigns a fixed complement of flights to an airport-external city market for future forecast years. The number of flights assigned varies with the nonstop distance, the target load factors, with the density of the market in terms of one-day daily "on-board" passengers and with the specific airport from which the flight departs.[2/]

Since the scheduling of airplanes is performed on the basis of on-board passenger loads, as opposed to the local O&D traffic, it is necessary to develop estimates of on-board passenger loads from the forecast base of local O&D demand. The local O&D base was derived from the FAA's official forecast of regional enplanements. The COG study developed these estimates using historical relationships between local O&D traffic, enplaned traffic, and on-board traffic in each market and these sets of factors were adopted for purposes of the present study.

Next in the analytical sequence, the passengers in a given market (local zone-external city) are distributed throughout the hours of the operating day in accordance with a specific passenger preference schedule for each hour of departure, as determined from historical study results. From the set of daily departures picked to serve the market, using the scheduling tables, the largest airplane is assigned to the greatest passenger demand interval (hour of the day), drawing passengers from that interval and from the following interval(s) until the target load factor is reached. The distribution of passenger demand by hour of the day is adjusted to delete the

---

1/ Air Transport Association of America, ATA Airline Airport Demand Forecasts, Washington, D.C., July 1969, pp. 104-123.

2/ In this study, Washington National was limited in types of aircraft permitted (with the limits varying from case to case), and was generally assumed to operate at higher load factors than the other area airports.

ssengers accommodated on this first flight, and the process is repeated until all departing flights in the market have been scheduled by hourly intervals of the day.

The next procedure is to test whether or not a shifting in any or all of the flights initially scheduled, will cause a reduction in average schedule waiting time.[1/] Each flight in each market is tested sequentially to determine whether a shift to another hour would improve schedule waiting time. If so, the shift is made.

Step 3: Reassignment of Traffic to Airports

In Step 1, the model assigned passengers to airports on the basis of minimum total travel time for the roundtrip, without regard to schedule frequency at the various airports, which had not yet been determined. However, it is not realistic to assume that airport choice is unaffected by the frequency of service to the destination in question. Therefore, at this point the assignment rules are broadened to encompass the effects of the flight schedules generated in Step 2. The average schedule waiting time for each airport-external city combination is computed, and is added to the travel times used in the initial passenger assignment.[2/] For each local zone-external city combination, passengers are reassigned to that airport which produces the minimum of travel time plus schedule waiting time. The airports are then rescheduled in accordance

---

1/ Average time interval between schedule flights in a given market (expressed in minutes).

2/ Weights can be assigned to the schedule waiting times to express their importance in the passenger decision process relative to actual travel time. In this study, it was assumed that waiting time should be "discounted" relative to travel time, by a factor or 60 percent. Other discount factors were tested and rejected as it appeared that a weight of 0.4 produced intuitively reasonable results so far as the traffic and activity distributions between IAD and BWI were concerned.

with the procedures described in Step 2, and a new schedule waiting time is derived for each airport-external city combination from the flight schedules produced by this second iteration.

The process is repeated until the analyst is satisfied that the marginal changes in the levels of airport demand, or airport-external city demand are inconsequential for his purposes, given the computer costs of allowing further iterations. In this case, the process was terminated at the end of the third iteration, since test runs with fourth iterations produced only marginal shifts in airport demand.

Step 4: Application of Capacity Limits

At the end of the third iteration- a set of flight schedules is produced for each airport-external city, by time of day and by type of aircraft. Up to this point, the model has processed without constraints on airport capacity, basing airport assignment solely on passengers' preferences for the available airports.

At this point, the model applies the actual or projected capacity limitations of the airports to determine the most over-capacity airport and to remove flights in any hours where that airport has been scheduled beyond its capacity on the last iteration. Since the model only schedules departing flights explicitly, the limits applied are hourly departure capacities allocable to domestic scheduled operations at each of the airports. These hourly departures capacities may vary during the course of a day, depending on the peaking characteristics of the air traffic in and out of the metropolitan area.1/

Using the hourly departure capacity levels for each airport, the number of excess flights2/ is summed over all hours of the day to determine which airport is scheduled most over its capacity (designated Airport A in this discussion). The

---

1/ While the maximum number of operations at each airport does not vary by hour of day, the proportion of operations available for departing flights varies from hour to hour.

2/ "Excess flights" denotes the number of departures scheduled in a given hour which exceed the airport's departure capacity for that hour.

algorithm which removes or cancels flights at the most over-capacity airport proceeds in the following manner:

(a) Any flight which falls below a minimum load factor[1/] and which is the only flight to an external city from the airport is cancelled.

(b) The latest hourly interval of the day which has excess flights is selected.

(c) Excess flights are removed proportionally from all markets served in that interval, with flights using the smallest aircraft removed first in each market.[2/] In the case of markets having the same number of flights, the one having the smallest aircraft scheduled is treated first. If still tied, the market of the longest distance is processed first.

(d) If there is available departure capacity at Airport A in a nearby hour,[3/] the removed flight is shifted to that hour. If there is no such capacity available at Airport A, the flight is cancelled.

(e) The number of passengers on each flight cancelled in (d) above is calculated by applying the average load factor for that market to the seating capacity of the aircraft.

(f) The on-board passenger load computed in (e) above is scaled back to the corresponding number of local O&D passengers. Using the distribution by local zone of all passengers in this airport-

---

1/ In this study, a 30 percent minimum load factor was used.

2/ In markets with more than two flights initially scheduled in an interval, at least two of those flights must be left in that interval unless there is no other way to remove all the excess flights in that hour.

3/ Defined in this study as two hours before or after the interval in question.

external city market, the local O&D passengers from each cancelled flight are redistributed to the local zones within the region.

(g) The next latest hourly interval of the day which has excess flights scheduled is selected and processes in accordance with steps (c) through (f).

(h) When all of the hours scheduled with excess flights have been processes, the passenger volume and schedule of flight activity at Airport A is considered final, and will not be changed during the remainder of this operation of the model.

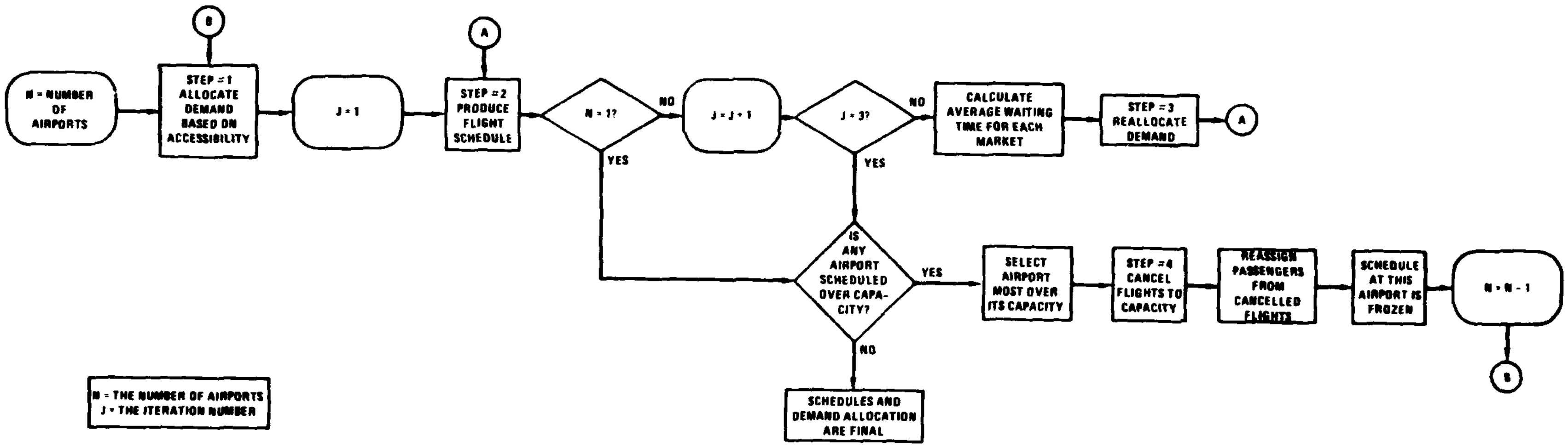
Step 5: Reiteration

With the finalization of schedules and traffic at Airport A, all schedules at the remaining airports are cancelled and the local O&D passengers assigned to those airports are redistributed among the local originating zones. Together with the passengers removed from Airport A, these comprise a new matrix of zone-external city demand, which exclude those passengers accommodated on flights at Airport A.

The model then repeats the first four steps as many times as necessary, each time finalizing operations at one airport until each airport in the region has been scheduled within its capacity. At that point, the operation of the model is completed.

A schematic diagram of the model processes appears on the following page.

SCHEMATIC DIAGRAM OF PASSENGER ALLOCATION MODEL



SECTION III: INPUT DATA AND ASSUMPTIONS

As in any analytical procedure, the output of this model can be no better than the input data and assumptions which are fed into it. The operation of the model requires substantial amounts of data, embodying passenger preferences, airline scheduling behavior, airport characteristics, traffic flows, travel times and costs, and operating policies. This section describes the various input data used in the modelling process as well as the sources and underlying assumptions.

Traffic Forecasts

As indicated above, the model requires forecasts at a micro level; viz. at the local zone-external city level. For purposes of this study, therefore, we began the process by disaggregating the FAA's 1990 forecast of 17,495,000 enplanements for the region (including commuter) into the local zone-external city markets. First, the forecast of regional enplanements was converted to an estimate of regional true originating passengers of 13,810,000 using the system. The relationship of enplaned to originations was developed in the COG study. We then disaggregated the originations total into the local zone-external city markets. The estimated 1990 market shares of each zone-external city combination were again based upon the analysis contained in the COG study.

In the COG study, the distribution of traffic flows among external cities was satisfactorily estimated, using regression analysis relating traffic volume to socioeconomic characteristics of the external areas. Since the model only projects airline schedules on nonstop segments from the local region, it was necessary to consolidate all the origin-destination traffic flows over the segments projected to receive certificated nonstop

service in the forecast period.[1/] In addition, commuter traffic was forecast separately and distributed among markets based on historical scheduling patterns. The resulting distribution of traffic estimates is shown in Table 1 for the forecast year 1990.

The COG distribution of forecast originations within the Washington/Baltimore region was based on 72 "aviation analysis zones", which are aggregations of TPD's (Transportation Planning Districts) for the Washington SMSA and RPD's (Regional Planning Districts) for the Baltimore SMSA. An additional six zones (zones 73-78) were used to represent outlying areas of Maryland and Virginia, as well as neighboring states. Separate statistical forecasting equations were developed for each of three subregions within the area (Baltimore City, Baltimore Metro, and Washington Metro) for government business, non-government business, and all other trips, based on employment, population, and income date. A separate calibration was performed for zones 73-78. The results of these forecasts were used to determine the percentage distribution of traffic among the local zones, since both the total traffic volume and the flows to external cities were projected independently. Table 2 summarizes the estimated zonal distribution for the forecast year.

The model also requires "scaling factors" for transforming local O&D traffic to the corresponding number of enplanements and on-board passengers. These factors were estimated for COG for an historical period by relating CAB service segment data [2/] to true O&D traffic volumes from the CAB O&D Survey (Table 8) for each Washington/Baltimore-external city market that received

---

1/ The projected nonstop markets are shown in Table 1. They consist mostly of markets presently served, with the addition of a small number of relatively long-haul markets. For the purpose of the study, Harrisburg and Richmond, which are served by both certificated and commuter carriers, are considered commuter markets.

2/ On-board and enplaned traffic volumes over each nonstop segment from ER-586 reports.

nonstop service. For those markets not yet receiving such service, the scaling factors were derived as weighted averages of those currently experienced over logical gateways.[1/] Table 3 summarizes the enplaned and on-board scaling factors for each of the 72 external cities used in this study.

Passenger Departure Preference

The passenger preference for flight departures by time of day, used to determine the flight schedules at each airport, was derived from an internal study of one of the major trunk airlines. This study allowed a compartmentalization of preferences by four different categories of trip length: 0-599 miles; 600-1199 miles; 1200-2199 miles; and over 2200 miles. The preference distributions for the four mileage categories are shown in Table 4.

Access/Egress Time and Cost

The key factors that affect a passenger's choice of airport and that vary from airport to airport are:

- access/egress time and cost
- time spent at the airport (in terminal processing and on the aircraft)
- schedule frequency.

The first two of these are inputs to the model, while the third is produced by the model itself.

The basic access time and cost measures were developed by Alan M. Voorhees & Associates, Inc. for the Maryland Department of Transportation's statewide airport system study (1975). The Voorhees work became an adopted input to the COG study. Voorhees prepared a series of alternative access systems reflecting various assumptions as to the nature of highway and transit facilities in the forecast years. For each alternative, an access utility was estimated for each zone-to-airport combination, using the following procedure.

1/ Commuter markets were assumed to have scaling factors of 1.0 with the exception of those which have actually had certificated service. Scaling factors for the latter are a weighted average of the historical factors from certificated service and the 1.0 assumed for commuter service.

1. A computerized mathematical representation of the highway and transit networks was constructed, and zone-to-airport travel times and costs were estimated for each mode using minimum path algorithms.

2. Access utility, an index value statistically combining time and cost, was determined for each mode/zone/airport combination. Based on these utilities, the distribution of traffic among other modes was estimated for each zone-to-airport combination.

3. The access utility for each mode was weighted by the modal split percentages to produce a weighted access utility for each zone-to-airport combination.

4. The weighted access utilities were converted into equivalent minutes so as to be comparable with other time factors used in the model.[1/]

The 1990 local transporation network adopted for this analysis incorporated the following features in addition to the system which exists today:

- <u>Highway</u>
  - Washington -- existing system plus:
    - -- I-595 in Virginia south of D.C.
    - -- Sully Road
  - Baltimore -- existing system plus:
    - -- Md. 46 extended to link airport access road and I-95 at Md. 166
    - -- Outer Harbor Crossing
    - -- 3A System in Baltimore
    - -- I-95 east from Hanover Street
    - -- I-70 in Baltimore City
    - -- I-83 extension
- <u>Transit</u>
  - Baltimore -- Section A of Metro only (Phase I from CBD north to City Line)

1/ Access utility, which is a negative number, was divided by -.085 to produce equivalent minutes.

- Washington -- Cutback Metro - 50 miles (only those sections now under construction per OMB recommendation)

- Limousine
  - Limo service from all zones with existing service and all zones with over 2.5 percent of an airport's passenger volume in 1973.

The 1990 access measures for each zone-to-airport combination are shown in Table 5. Egress times are assumed to be identical to access time.

Airport Time

The time passengers spend at an airport prior to departure and after arrival is affected by terminal configuration and congestion, as well as by runway layout and airspace congestion. The types of time factors involved include:[1/]

- Terminal walking, waiting, and processing time;
- Time required to travel from the terminal to the aircraft;
- Ground congestion delays; and
- Time spent on the aircraft prior to takeoff.

Time spent in these activities is affected both by the nature of the normal processes at each airport and by the likelihood of delays due to congestion and other factors.

Since no consistent time estimates were available for the three major existing airports, the study team adopted FAA consensus estimates of time differentials between airports based on a review of airport configurations and processes.[2/] These time differentials, which encompass all types of time spent at the airport during the course of a roundtrip flight, are as follows:

1/ Time spent prior to reaching the terminal (i.e., parking or travelling within the airport) was considered as part of access time.

2/ The total amount of time an average passenger spends at each airport is not significant for use in the model, since only the differences between airports affect the results.

Airport	Number of Minutes
BWI	+ 5
DCA	+20
IAD	0

Schedule Waiting Time

Schedule waiting time is calculated by the model for each market at each airport, based on the passenger departure preferences described earlier and on the flight schedules generated by the model. It represents the difference between the time a passenger would prefer to depart and the time at which he must depart as a result of the flight schedules.[1/] Thus, it is more a measure of inconvenience than of actual travel time. Therefore, the model provides the capability for discounting the impact of waiting time relative to travel time by the application of weighting factors for various distance brackets.[2/] After discussion with FAA personnel and several test runs using various weighting factors, it was decided to use a constant factor of 0.4 for all mileage blocks.

1/ The waiting time calculation assumes that a passenger's arrival time at his destination is the controlling factor in his choice of flight. Therefore, if a flight is not available at the preferred hour, a passenger will choose the next earlier departure and incur a waiting time at his destination.

2/ Previous regression analyses were performed to calibrate a series of passenger demand estimating equations. One set of the calibrations considered total roundtrip time as a single composite variable and another set considered time as two variables; namely, schedule waiting time and all other trip time. The results indicated a lower elasticity with respect to schedule waiting time than was true for other trip time. This suggests that ground accessibility has a greater impact than flight frequency on passengers' choice of airports.

Summary of Time and Cost Components

The distribution of passengers among airports is produced in the model based on total roundtrip travel time plus, on most iterations, schedule waiting time. The time components that vary among airports are critical to the results of the process and have been described above. In sum, they are:

- Local access/egress time (computed twice for both ends of the trip).
- Local airport facilitation and delay time (inbound and outbound).
- Average schedule waiting time (inbound and outbound).

Other components of total travel time are not significantly different between the three local airports and do not affect the distribution of passengers. These factors are:

- Roundtrip flight time (except for airport delays).
- External city airport facilitation and delay time.
- External city access/egress time.

The only cost factor used in this application of the model was local access/egress cost, which was incorporated by use of the access utility measure. Other costs (i.e., air fare and external city access/egress cost) would not affect the passenger distribution.

Operating Restrictions

The model accepts various types of restrictions on airport operations, including the markets that can be served, the types of aircraft permitted to operate, and the hours of operation. The latter two are governed respectively by the flight scheduling rules and capacity limitations which are discussed below.

In this study, market limitations were applied at Washington National. The limitations at National consist of the present 600-mile perimeter rule for nonstop service, with the exception of the seven "grandfather cities": St. Louis, Minneapolis/St. Paul, Miami, Orlando, Tampa, West Palm Beach, and Memphis.

Airport Capacity Limitations

For use in the model, airport capacities must first be defined in terms of operations per hour available for scheduled domestic passenger service. These must then be converted into hourly departure capacities based on an actual or assumed allocation of capacity between departures and arrivals in each hour. The baseline airport capacities used in this study were as follows:1/

Airport	Number of Hourly Operations
DCA - certificated	42 2/
- commuter	8
BWI	53
IAD	83

The capacities for BWI and Dulles are based on the data provided in the COG study, where one slot per hour at Dulles was assumed for international or charter service.

The allocation of capacity between departures and arrivals at the three existing airports was based on the proportions currently experienced at those airports. However, some adjustments were necessary for BWI and Dulles, because tne small number of operations in some hours makes the present distribution meaningless.

The resulting hourly departure capacities for each airport in the baseline case are shown in Table 6.

Flight Scheduling Rules

The flight scheduling rules, which are applied as part of Step 2 of the modelling process, 3/ assign a fixed complement of flights, by aircraft type, to each airport-external city combination. The flight assignment is a function of both passenger

---

1/ The model generally assumes a 17-hour operating day (7:00 AM-12:00 AM). However, departure schedules were assumed to terminate between 10:00 PM and 11:00 PM at Washington National in the baseline case.

2/ Forty slots for scheduled flights plus an allowance for two additional slots for extra sections of the Eastern shuttle.

3/ See pages 6 and 7 of this report.

volume and nonstop distance, and is also subject to operating constraints at each airport. Thus, because of the limitations on aircraft size at Washington National,[1/] separate rules were developed for that airport under two different assumptions: (1) that current operating restrictions will remain in effect (for baseline runs), and (2) that widebodied jets will be permitted to the extent operationally feasible (for various future alternatives). In addition, separate rules are established for commuter operations, and for each of the following distance categories : 0-299 miles, 300-799 miles, 800-1299 miles, 1300-1599 miles, and 1600 miles and over.

The scheduling rules are based on the following potential mix of aircraft for the forecast year, expressed in terms of passenger seating capacity:

	Number of Seats - 1990
- Certificated Carriers	95
	125
	200
	250
	350
	500
- Commuter	30
	50

They are further premised on the following assumptions:

- The average overall load factor for certificated carriers for the region will be approximately 65% in 1990.
- The average load factor at Washington National will be higher than those at BWI and Dulles.
- The average load factors on commuter operations will be lower than those on conventional certificated service.
- Short-haul markets will tend to have higher load factors than long-haul markets.

1/ The present maximum size of commercial and other jets at DCA is the 727-200 class of three-engine jet aircraft; no four-engine jet aircraft are allowed.

- High-density markets will tend to experience higher load factors than low-density markets.

The flight scheduling rules used for 1990 are shown in Table 7, by airport and by mileage range.

Load Factor Variation By Time of Day

In order to project facilities requirements, it is important to realistically assess the peaking characteristics of passenger flows at each airport. The peaking phenomenon is reflected in three different aspects of an airport's operations in any given period of time:

- the number of aircraft departures
- the size of the aircraft
- the load factor

The first two of these are governed by the scheduling process described in the previous section. The last -- load factor -- is varied from hour to hour based on the following set of weightings applied to the flights in each airport-external city market:

Time Period	Weighting
7:00 AM - 9:59 AM	1.10
10:00 AM - 2:59 PM	.95
3:00 PM - 7:59 PM	1.10
8:00 PM - 12:00 AM	.90

While the average load factor for any market is determined by the scheduling rules applicable to that market, the hourly variations are determined according to these proportions.

SECTION IV: 1990 BASELINE RUN

As a basis for analysis of the various system alternatives, projections assuming continuation of the present system were performed for 1990. The "baseline" or "status quo" projection is based on the FAA forecast future traffic levels and flight scheduling rules, but it assumes no change from the present system with regard to number and capacity of airports, operating rules and restrictions.

The 1990 projected distribution of scheduled domestic traffic and aircraft operations among the existing airports is shown below and compared to the actual 1974 experience.

Annual Passenger Enplanements (millions):	Actual 1974 1/	1990 Projection	Average Annual Rate of Increase 1974-1990
DCA	5.6	8.7	2.8%
BWI	1.3	3.6	6.6
IAD	0.9	5.4	11.8
Total	7.8	17.7	5.3%
Annual Aircraft Operations (000):			
DCA	235	261	0.7%
BWI	98	116	1.1
IAD	52	139	6.3
Total	385	516	1.8%

These figures include commuter services, but do not include international, charter, all-cargo, military, and general aviation activity. This traffic was introduced later in the analysis at a fixed level. The most rapid growth is projected for Dulles with somewhat less at BWI, and a relatively small amount at National. The limited growth at National is obviously attributable to the scarcity of unused capacity, in contrast to Dulles and

1/ Source: CAB/FAA, Airport Activity Statistics, December 1974 and FAA reports on third-level activity.

BWI, which are currently underutilized.

The projected increase in enplanements exceeds the forecase increase in aircraft operations at all airports, because increases are projected in both aircraft size and passenger load factor. The 1990 forecast number of departures by each aircraft type at each airport is shown in Table 8.

The projected shifts in traffic flows and volume of activity among the three airports stem from two key factors. First, even in 1974 there was little available capacity for additional flights at National, and as a result, traffic growth is limited almost entirely to that which can be accommodated by use of larger aircraft and higher load factors. However, since operating rules limit the size of the aircraft that can use National, even that avenue of growth is sharply restricted. Consequently, little of the region's traffic growth can be accommodated at National. Thus, by 1990, Dulles is expected to account for 30 percent of the area's enplanements, compared to 12 percent in 1974. At the same time, BWI's share is forecast to grow from 17 percent to 20 percent, while National's share will decline from 72 percent to 49 percent.

FORECAST 1990 O&D TRAFFIC BY EXTERNAL CITY

City	Forecast Annual Originations - 1990 (000)
Trunk or Local Service Markets:	
Albuquerque, NM	72
Atlanta, GA	604
Austin, TX	66
Birmingham, AL	49
Boston, MA	1058
Buffalo, NY	119
Charlotte, NC	100
Chicago, IL	934
Cincinnati, OH	142
Cleveland, OH	285
Columbia, SC	41
Columbus, GA	116
Columbus, OH	129
Dallas, TX	311
Dayton, OH	97
Denver, CO	225
Detroit, MI	451
Greensboro, NC	74
Greenville, SC	36
Hartford, CT	288
Honolulu, HI	89
Houston, TX	167
Huntsville, AL	68
Indianapolis, IN	135
Jackson, MS	29
Jacksonville, FL	90
Kansas City, MO	110
Knoxville, TN	43
Las Vegas, NV	124
Little Rock, AR	31
Los Angeles, CA	556
Louisville, KY	57
Madison, WI	26
Memphis, TN	107
Miami, FL	521

FORECAST 1990 O&D TRAFFIC BY EXTERNAL CITY

City	Forecast Annual Originations - 1990 (000)
Trunk or Local Service Markets (Cont'd.)	
Milwaukee, WI	83
Minneapolis, MN	180
Mobile, AL	58
Montgomery, AL	27
Nashville, TN	94
New Orleans, LA	156
New York, NY	2150
Norfolk, VA	149
Oklahoma City, OK	54
Omaha, NE	47
Orlando, FL	282
Philadelphia, PA	156
Phoenix, AZ	88
Pittsburgh, PA	231
Portland, OR	54
Raleigh, NC	104
Roanoke, VA	105
Rochester, NY	113
St. Louis, MO	191
Salt Lake City, UT	66
San Antonio, TX	69
San Diego, CA	136
San Francisco, CA	410
Schenectedy/Troy, NY	103
Seattle, WA	119
Syracuse, NY	96
Tallahassee, FL	34
Tampa, FL	203
Tucson, AZ	74
Tulsa, OK	53
West Palm Beach, FL	94
Wilmington, NC	30
Commuter Markets:	
Hagerstown, MD	41
Harrisburg, PA	53
Richmond, VA	100
Salisbury, MD	105
Other Commuter	352
TOTAL	13,810

NOTE: Total may not add due to rounding.

FORECAST DISTRIBUTION OF 1990 LOCAL ORIGINATIONS BY LOCAL ZONE

Zone Number	Zone Description	Component RPD's/TPD's	Forecast Local Originations - 1990
Baltimore Region:			
1	Downtown Baltimore	118	214
2	East Baltimore	111, 119	55
3	Baltimore-Druid Hill	109,110,117	48
4	Baltimore-Ten Hills	114-116, 122	30
5	South Baltimore	123-216	23
6	Baltimore-Canton Area	120, 121	32
7	Northeast Baltimore	106, 112, 113	28
8	Baltimore-Roland Park	103-105	151
9	Baltimore-Park Heights	101, 102, 107, 108	94
10	Catonsville	319, 323-325	108
11	Pikesville	307, 313	51
12	Towson Area	308, 314, 315	130
13	Dundalk Perry	316-318, 320, 321, 326	36
14	Middle River	322, 327-331	66
15	Glen Burnie	201, 203	79
16	Baltimore-Washington International	202	43
17	Mountain Road	204, 207	33
18	Severna Park	206, 212, 213	99
19	Annapolis	214, 215	104
20	Crofton Area	211, 216, 217	29
21	Fort Meade Area	205, 208-210	98
22	Columbia	605, 606	110
23	Other Howard County	601-604, 607	58
24	Reistertown	303, 306, 311, 312	97
25	Timonium Area	304, 305, 309, 310	54
26	Aberdeen Area	504-507	59
27	Other Harford	301, 302, 501-503	48
28	Carroll County	401-406	80

FORECAST DISTRIBUTION OF 1990 LOCAL ORIGINATIONS BY LOCAL ZONE

Zone Number	Zone Description	Component RPD's/TPD's	Forecast Local Originations - 1990
Washington Region:			
29	Downtown Washington	1-6	1050
30	Union Station	103-105	146
31	Southwest Washington	106-108	164
32	Pentagon Area	131-133	153
33	Anacostia West	200, 208, 209	181
34	Georgetown	101, 102	211
35	Rosslyn Area	235-237	142
36	South Arlington	233, 234, 333, 334	113
37	Crystal City	232	387
38	National Airport	231	101
39	Old Alexandria	332, 341, 342	167
40	Anacostia East	300, 308, 309	64
41	New York Avenue	207, 307	257
42	Northeast Washington	205, 206, 305, 306	113
43	Rock Creek Park	203, 204, 303, 304	639
44	Northwest Washington	201, 202, 301, 302	282
45	North Arlington	335-337	119
46	Springfield	541, 551-553	420
47	Duke-Alexandria	442, 443, 452, 453	218
48	Falls Church	454-455	138
49	Bethesda Area	411-413	358
50	Silver Spring	414-416	146
51	College Park	421-423	229
52	Seat Pleasant	424, 426	255
53	Suitland Area	427, 428, 492	43
54	Fort Belvoir	651, 653, 751, 753	273
55	Fairfax City	554, 555, 654, 655	254
56	Vienna Area	556, 557, 656, 657	284
57	Potomac Area	511, 512, 611, 612	289
58	Rockville	513, 514, 613, 614	309
59	Wheaton Area	515, 516	167
60	NE Montgomery County	615, 616, 715	156
61	Beltsville	521, 523, 621, 623	178
62	Bowie Area	524, 525, 624, 625	318
63	Upper Marlboro	526, 527, 626, 627, 827	215
64	Oxon Hill	528, 529, 628, 629, 828	247
65	West Fairfax County	754-756	69
66	Dulles International Airport	766	0
67	Reston Area	757, 767	432
68	Germantown	711, 712, 811, 812	318

FORECAST DISTRIBUTION OF 1990 LOCAL ORIGINATIONS BY LOCAL ZONE

Zone Number	Zone Description	Component RPD's/TPD's	Forecast Local Originations - 1990
Washington Region:			
69	Prince William County	771, 773-775, 871, 873-875	776
70	Loudoun County	865-867	17
71	Gaithersburg	713, 714, 813	224
72	McLean Area	456, 457	153
73	Other Maryland		287
74	Other Virginia		392
75	West Virginia		23
76	Pennsylvania		228
77	Delaware		36
78	New Jersey		4
	TOTAL		13,810

NOTE: Total may not add due to rounding.

ESTIMATED RATIOS OF ENPLANED AND ON-BOARD TRAFFIC TO LOCAL O&D PASSENGERS

City	Enplaned	On-Board
Albuquerque, NM	1.2358	1.3125
Atlanta, GA	1.8030	2.0327
Austin, TX	1.0165	1.0352
Birmingham, AL	1.8030	2.0327
Boston, MA	1.2705	1.5758
Buffalo, NY	1.4045	1.4045
Charlotte, N.C.	1.6428	1.9412
Chicago, IL	1.3365	1.4572
Cincinnati, OH	1.4751	1.9372
Cleveland, OH	1.9107	1.9107
Columbia, SC	0.6265	0.7281
Columbus, GA	0.3609	0.7404
Columbus, OH	1.0680	1.0680
Dallas, TX	1.2165	1.6345
Dayton, OH	1.1186	1.1186
Denver, CO	1.0967	1.1008
Detroit, MI	1.4198	1.4198
Greensboro, NC	1.9036	1.9655
Greenville, SC	1.2187	1.2187
Hartford, CT	1.1297	1.3734
Honolulu, HI	1.1901	1.2547
Houston, TX	0.9184	1.0159
Huntsville, AL	0.6594	0.6594
Indianapolis, IN	1.1303	1.5610
Jackson, MS	1.5887	1.8879
Jacksonville, FL	1.0531	1.4751
Kansas City, MO	0.9197	0.9197
Knoxville, TN	2.4775	2.4775
Las Vegas, NV	1.5878	1.5878
Little Rock, AR	1.4580	1.8281
Los Angeles, CA	1.0274	1.0867
Louisville, KY	1.0712	1.1774
Madison, WI	1.2984	1.3802
Memphis, TN	1.3743	1.7430
Miami, FL	0.9553	1.1276
Milwaukee, WI	0.8337	0.8337
Minneapolis, MN	1.1468	1.1468
Mobile, AL	1.5415	1.7613
Montgomery, AL	1.8030	2.0327
Nashville, TN	1.7930	2.1687

ESTIMATED RATIOS OF ENPLANED AND ON-BOARD TRAFFIC
TO LOCAL O&D PASSENGERS

City	Enplaned	On-Board
New Orleans, LA	0.9240	0.9657
New York, NY	1.2221	1.4870
Norfolk, VA	2.4623	2.8259
Oklahoma City, OK	1.2052	1.3528
Omåha, NE	1.2302	1.3146
Orlando, FL	0.7787	0.9755
Philadelphia, PA	1.7081	2.3809
Phoenix, AZ	0.9196	1.1848
Pittsburgh, PA	2.2604	2.5091
Portland, OR	1.2155	1.2580
Raleigh, NC	2.3899	2.5247
Roanoke, VA	2.6288	2.7931
Rochester, NY	1.3881	1.4499
St. Louis, MO	0.7861	0.7988
Salt Lake City, UT	1.2923	1.3750
San Antonio, TX	1.1271	1.4490
San Diego, CA	1.3523	1.7101
San Francisco, CA	1.2131	1.2131
Schenectedy/Troy, NY	1.1759	1.4302
Seattle, WA	1.2015	1.2015
Syracuse, NY	1.5869	1.8003
Tallahassee, FL	1.2896	1.6070
Tampa, FL	0.5953	0.7849
Tucson, AZ	1.1401	1.3779
Tulsa, OK	1.1895	1.7127
West Palm Beach	0.9553	1.1276
Wilmington, NC	2.1092	2.2652
Hagerstown, MD	1.0000	1.0000
Harrisburg, PA	1.0233	1.0455
Richmond, VA	1.0903	1.2880
Salisbury, MD	1.0000	1.0000
Other Commuter	1.0440	1.0572

PASSENGER DEPARTURE PREFERENCES BY TIME OF DAY

Time of Day	Distance Range :	Percent of Daily Traffic 0-599 Miles	600-1199 Miles	1200-2199 Miles	Over 2200 Miles
7:00-7:59 AM		5.4%	4.4%	0.0%	0.0%
8:00-8:59		6.2	5.0	5.6	5.1
9:00-9:59		6.8	5.8	6.5	5.8
10:00-10:59		6.4	6.4	7.4	6.7
11:00-11:59		6.1	6.4	7.9	7.9
12:00-12:59 PM		5.7	6.1	7.8	8.2
1:00-1:59		5.6	5.6	7.2	7.7
2:00-2:59		6.0	5.8	6.7	7.1
3:00-3:59		6.6	6.3	6.3	6.8
4:00-4:59		7.1	7.4	6.2	6.8
5:00-5:59		7.1	8.0	6.5	6.9
6:00-6:59		6.9	7.4	6.7	6.6
7:00-7:59		6.5	6.5	6.2	6.1
8:00-8:59		6.1	6.1	5.7	5.7
9:00-9:59		5.3	5.7	5.5	5.2
10:00-10:59		4.3	5.0	5.3	5.0
11:00-11:59		1.9	2.1	2.5	2.4

AVERAGE LOCAL ACCESS MEASURES - 1990
(In Equivalent Minutes)

Local Zone	Airport: DCA	BWI	IAD
New York Avenue	18	79	81
Northeast Washington, D.C.	21	90	84
Rock Creek Park	21	93	58
Northwest Washington, D.C.	16	104	54
North Arlington	16	126	47
Springfield	17	121	61
Duke-Alexandria	10	124	53
Falls Church	21	124	43
Bethesda Area	33	96	49
Silver Spring	30	75	64
College Park	43	68	85
Seat Pleasant	33	71	97
Suitland Area	18	100	86
Fort Belvoir	40	134	60
Fairfax City	40	127	36
Vienna Area	47	118	20
Potomac Area	58	103	58
Rockville	53	95	60
Wheaton Area	43	73	74
Northeast Montgomery Co.	56	86	81
Beltsville	55	51	85
Bowie Area	47	58	99
Upper Marlboro	56	95	107
Oxon Hill	27	113	92
West Fairfax Co.	68	135	11
Dulles International Airport	74	133	17
Reston Area	70	131	9
Germantown	102	131	74
Prince William Co.	94	155	53
Loudon County	116	154	48
Gaithersburg	43	93	50
McLean Area	26	116	35
Other Maryland	172	134	174
Other Virginia	134	176	125
West Virginia	160	136	159
Pennsylvania	175	142	178
Delaware	171	132	173
New Jersey	171	132	173

AVERAGE LOCAL ACCESS MEASURES - 1990
(In Equivalent Minutes)

Local Zone	Airport: DCA	BWI	IAD
Downtown Baltimore	125	17	126
East Baltimore	130	22	130
Baltimore-Druid Hill	129	26	125
Baltimore-Ten Hills	121	15	119
South Baltimore	123	12	125
Baltimore-Canton Area	130	18	127
Northeast Baltimore	124	36	122
Baltimore-Roland Park	138	37	131
Baltimore-Park Heights	132	31	128
Catonsville	123	32	122
Pikesville	141	55	137
Towson Area	133	50	129
Dundalk Perry	118	40	118
Middle River	136	45	131
Glen Burnie	124	5	125
Baltimore-Washington Int'l	108	18	118
Mountain Road	135	21	140
Severna Park	115	28	130
Annapolis	114	62	134
Crofton Area	108	72	123
Fort Meade Area	92	18	109
Columbia	103	23	109
Other Howard County	105	61	109
Reistertown	140	59	136
Timonium Area	142	78	138
Aberdeen Area	136	64	131
Other Harford County	139	76	134
Carroll County	142	102	136
Downtown Washington, D.C.	4	58	58
Union Station	8	92	67
Southwest Washington, D.C.	2	93	69
Pentagon Area	3	104	61
Anacostia West	6	91	62
Georgetown	6	107	59
Rosslyn Area	8	109	56
South Arlington	9	107	67
Crystal City	10	106	66
National Airport	18	107	72
Old Alexandria	0	119	66
Anacostia East	13	24	82

ESTIMATED HOURLY DEPARTURE CAPACITIES
1990 Baseline

Hour	DCA Certificated	DCA Commuter	BWI	IAD
7:00-7:59 AM	24	6	20	20
8:00-8:59	20	4	25	25
9:00-9:59	20	3	31	48
10:00-10:59	20	4	30	51
11:00-11:59	20	3	33	48
12:00-12:59 PM	24	5	26	40
1:00-1:59	20	4	33	52
2:00-2:59	23	4	23	40
3:00-3:59	21	5	27	52
4:00-4:59	20	4	25	40
5:00-5:59	24	5	29	52
6:00-6:59	19	4	25	46
7:00-7:59	21	3	31	46
8:00-8:59	19	3	30	40
9:00-9:59	20	3	20	40
10:00-10:59	11	2	25	36
11:00-11:59	0	0	17	30

FLIGHT SCHEDULLING RULES - 1990

DCA: Under 300 Miles; Present Operating Rules

Number of One-Way Daily Passengers	Number of Daily Flights (By Aircraft Seating Capacity)					
	95	125	200	250	350	500
1-70	1	-	-	-	-	-
71-140	2	-	-	-	-	-
141-210	3	-	-	-	-	-
211-230	2	1	-	-	-	-
231-325	2	2	-	-	-	-
326-415	2	3	-	-	-	-
416-505	2	4	-	-	-	-
506-595	2	5	-	-	-	-
596-615	1	6	-	-	-	-
616-700	1	7	-	-	-	-
701-720	-	8	-	-	-	-
721-810	-	9	-	-	-	-
↓ ↓		↓				
+90 Pax		+1				

FLIGHT SCHEDULING RULES - 1990

DCA: 300 Miles and Over; Present Operating Rules

Number of One-Way Daily Passengers	Number of Daily Flights (By Aircraft Seating Capacity) 95	125	200	250	350	500
1-70	1	-	-	-	-	-
71-140	2	-	-	-	-	-
141-210	3	-	-	-	-	-
211-230	2	1	-	-	-	-
231-325	2	2	-	-	-	-
326-415	2	3	-	-	-	-
416-505	2	4	-	-	-	-
506-595	2	5	-	-	-	-
596-615	1	6	-	-	-	-
616-695	1	7	-	-	-	-
696-715	-	8	-	-	-	-
716-805	-	9	-	-	-	-
↓ +90 Pax		↓ +1				

FLIGHT SCHEDULING RULES - 1990

DCA: Under 300 Miles; Widebodies Permitted

Number of One-Way Daily Passengers	Number of Daily Flights (By Aircraft Seating Capacity) 95	125	200	250	350	500
1-70	1	-	-	-	-	-
71-140	2	-	-	-	-	-
141-210	3	-	-	-	-	-
211-230	2	1	-	-	-	-
231-325	2	2	-	-	-	-
326-415	2	3	-	-	-	-
416-435	1	4	-	-	-	-
436-525	1	5	-	-	-	-
526-545	-	6	-	-	-	-
546-635	-	7	-	-	-	-
636-720	-	8	-	-	-	-
721-775	-	7	1	-	-	-
776-830	-	6	2	-	-	-
831-975	-	6	3	-	-	-
976-1030	-	5	4	-	-	-
1031-1085	-	4	5	-	-	-
1086-1230	-	4	6	-	-	-
1231-1265	-	4	5	1	-	-
1266-1355	-	3	5	2	-	-
1356-1505	-	3	6	2	-	-
1506-1595	-	2	6	3	-	-
1596-1745	-	2	7	3	-	-
1746-1895	-	2	8	3	-	-
1896-1930	-	2	7	4	-	-
1931-2105	-	2	7	5	-	-
2106-2155	-	1	8	5	-	-
2156-2195	-	1	7	6	-	-
2196-2255	-	-	8	6	-	-
2256-2295	-	-	7	7	-	-
2296-2330	-	-	6	8	-	-
2331-2485	-	-	7	8	-	-
2486-2520	-	-	6	9	-	-
2521-2555	-	-	5	10	-	-
2556-2590	-	-	4	11	-	-
2591-2770	-	-	4	12	-	-
2771-2950	-	-	4	13	-	-
2951-2985	-	-	3	14	-	-
2986-3165	-	-	3	15	-	-
3166-3200	-	-	2	16	-	-
3201-3225	-	-	1	17	-	-
3226-3270	-	-	-	18	-	-
3271-3453	-	-	-	19	-	-
↓ +183 Pax ↓				↓ +1		

FLIGHT SCHEDULING RULES - 1990

DCA: 300 Miles and Over; Widebodies Permitted

Number of One-Way Daily Passengers	Number of Daily Flights (By Aircraft Seating Capacity)					
	95	125	200	250	350	500
1-70	1	-	-	-	-	-
71-140	2	-	-	-	-	-
141-210	3	-	-	-	-	-
211-230	2	1	-	-	-	-
231-325	2	2	-	-	-	-
326-415	2	3	-	-	-	-
416-435	1	4	-	-	-	-
436-525	1	5	-	-	-	-
526-545	-	6	-	-	-	-
546-630	-	7	-	-	-	-
631-715	-	8	-	-	-	-
716-765	-	7	1	-	-	-
766-820	-	6	2	-	-	-
821-960	-	6	3	-	-	-
961-1015	-	5	4	-	-	-
1016-1065	-	4	5	-	-	-
1066-1210	-	4	6	-	-	-
1211-1240	-	4	5	1	-	-
1241-1330	-	3	5	2	-	-
1331-1475	-	3	6	2	-	-
1476-1565	-	2	6	3	-	-
1566-1710	-	2	7	3	-	-
1711-1860	-	2	8	3	-	-
1861-1890	-	2	7	4	-	-
1891-2065	-	2	7	5	-	-
2066-2110	-	1	8	5	-	-
2111-2150	-	1	7	6	-	-
2151-2205	-	-	8	6	-	-
2206-2245	-	-	7	7	-	-
2246-2280	-	-	6	8	-	-
2281-2430	-	-	7	8	-	-
2431-2465	-	-	6	9	-	-
2466-2500	-	-	5	10	-	-
2501-2530	-	-	4	11	-	-
2531-2710	-	-	4	12	-	-
2711-2885	-	-	4	13	-	-
2886-2920	-	-	3	14	-	-
2921-3095	-	-	3	15	-	-
3096-3125	-	-	2	16	-	-
3126-3160	-	-	1	17	-	-
3161-3195	-	-	-	18	-	-
3196-3378	-	-	-	19	-	-
↓ ↓ +183 Pax				↓ +1		

FLIGHT SCHEDULING RULES - 1990

BWI & IAD: Under 300 Miles

Number of One-Way Daily Passengers	Number of Daily Flights (By Aircraft Seating Capacity) 95	125	200	250	350	500
1-70	1	-	-	-	-	-
71-140	2	-	-	-	-	-
141-210	3	-	-	-	-	-
211-230	2	1	-	-	-	-
231-325	2	2	-	-	-	-
326-415	2	3	-	-	-	-
416-435	1	4	-	-	-	-
436-525	1	5	-	-	-	-
526-545	-	6	-	-	-	-
546-635	-	7	-	-	-	-
636-720	-	8	-	-	-	-
721-775	-	7	1	-	-	-
776-830	-	6	2	-	-	-
831-975	-	6	3	-	-	-
976-1030	-	5	4	-	-	-
1031-1085	-	4	5	-	-	-
1086-1230	-	4	6	-	-	-
1231-1265	-	4	5	1	-	-
1266-1355	-	3	5	2	-	-
1356-1505	-	3	6	2	-	-
1506-1595	-	2	6	3	-	-
1596-1745	-	2	7	3	-	-
1746-1895	-	2	8	3	-	-
1896-1930	-	2	7	4	-	-
1931-2040	-	2	6	4	1	-
2041-2180	-	2	7	4	1	-
2181-2235	-	2	6	5	1	-
2236-2340	-	2	5	5	2	-
2341-2430	-	1	5	6	2	-
2431-2485	-	-	6	6	2	-
2486-2520	-	-	5	7	2	-
2521-2695	-	-	5	8	2	-
2696-2765	-	-	5	7	3	-
2766-2800	-	-	4	8	3	-
2801-2985	-	-	4	9	3	-
2986-3090	-	-	3	9	4	-
3091-3270	-	-	3	10	4	-
3271-3345	-	-	3	9	5	-
3346-3525	-	-	3	10	5	-
3526-3705	-	-	3	11	5	-
3706-3780	-	-	3	10	6	-
3781-3965	-	-	3	11	6	-
3966-4225	-	-	3	11	7	-
↓ ↓ +260 Pax					↓ +1	

FLIGHT SCHEDULING RULES - 1990

BWI & IAD: 300-799 Miles

Number of One-Way Daily Passengers	Number of Daily Flights (By Aircraft Seating Capacity) 95	125	200	250	350	500
1-70	1	-	-	-	-	-
71-140	2	-	-	-	-	-
141-210	3	-	-	-	-	-
211-230	2	1	-	-	-	-
231-325	2	2	-	-	-	-
326-415	2	3	-	-	-	-
416-435	1	4	-	-	-	-
436-525	1	5	-	-	-	-
526-545	-	6	-	-	-	-
546-630	-	7	-	-	-	-
631-715	-	8	-	-	-	-
716-765	-	7	1	-	-	-
766-820	-	6	2	-	-	-
821-960	-	6	3	-	-	-
961-1015	-	5	4	-	-	-
1016-1065	-	4	5	-	-	-
1066-1210	-	4	6	-	-	-
1211-1240	-	4	5	1	-	-
1241-1330	-	3	5	2	-	-
1331-1475	-	3	6	2	-	-
1476-1565	-	2	6	3	-	-
1566-1710	-	2	7	3	-	-
1711-1860	-	2	8	3	-	-
1861-1890	-	2	7	4	-	-
1891-2000	-	2	6	4	1	-
2001-2135	-	2	7	4	1	-
2136-2190	-	2	6	5	1	-
2191-2290	-	2	5	5	2	-
2291-2380	-	1	5	6	2	-
2381-2430	-	-	6	6	2	-
2431-2465	-	-	5	7	2	-
2466-2635	-	-	5	8	2	-
2636-2705	-	-	5	7	3	-
2706-2735	-	-	4	8	3	-
2736-2920	-	-	4	9	3	-
2921-3020	-	-	3	9	4	-
3021-3195	-	-	3	10	4	-
3196-3265	-	-	3	9	5	-
3266-3440	-	-	3	10	5	-
3441-3615	-	-	3	11	5	-
3616-3685	-	-	3	10	6	-
3686-3865	-	-	3	11	6	-
3866-4125	-	-	3	11	7	-
+260 Pax					+1	

FLIGHT SCHEDULING RULES - 1990

BWI & IAD: 800-1299 Miles

Number of One-Way Daily Passengers	Number of Daily Flights (By Aircraft Seating Capacity) 95	125	200	250	350	500
1-70	1	-	-	-	-	-
71-140	2	-	-	-	-	-
141-210	3	-	-	-	-	-
211-230	2	1	-	-	-	-
231-320	2	2	-	-	-	-
321-400	2	3	-	-	-	-
401-415	1	4	-	-	-	-
416-495	1	5	-	-	-	-
496-515	-	6	-	-	-	-
516-595	-	7	-	-	-	-
596-675	-	8	-	-	-	-
676-725	-	7	1	-	-	-
726-775	-	6	2	-	-	-
776-900	-	6	3	-	-	-
901-950	-	5	4	-	-	-
951-1000	-	4	5	-	-	-
1001-1135	-	4	6	-	-	-
1136-1170	-	4	5	1	-	-
1171-1255	-	3	5	2	-	-
1256-1395	-	3	6	2	-	-
1396-1480	-	2	6	3	-	-
1481-1620	-	2	7	3	-	-
1621-1755	-	2	8	3	-	-
1756-1790	-	2	7	4	-	-
1791-1900	-	2	6	4	1	-
1901-2045	-	2	7	4	1	-
2046-2080	-	2	6	5	1	-
2081-2190	-	2	5	5	2	-
2191-2280	-	1	5	6	2	-
2281-2335	-	-	6	6	2	-
2336-2375	-	-	5	7	2	-
2376-2450	-	-	5	6	3	-
2451-2670	-	-	4	6	3	1
2671-2820	-	-	5	6	3	1
2821-3190	-	-	5	6	3	2
3191-3450	-	-	5	6	4	2
3451-3705	-	-	5	6	5	2
3706-3960	-	-	5	6	6	2
3961-4185	-	-	4	6	6	3
4186-4535	-	-	4	6	6	4
4536-4740	-	-	3	6	6	5
4741-4980	-	-	3	6	7	5
4981-5120	-	-	1	7	8	5
5121-5310	-	-	-	7	8	6
5311-5610	-	-	-	6	10	6
5611-5870	-	-	-	7	9	7
5871-6030	-	-	-	6	9	8
6031-6100	-	-	-	5	10	8
6101-6270	-	-	-	4	10	9
6271-6545	-	-	-	5	9	10
6546-6955	-	-	-	4	10	11
6956-7295	-	-	-	4	10	12
7296-7635	-	-	-	4	10	13
+340 Pax						+1

FLIGHT SCHEDULING RULES - 1990

BWI & IAD: 1300-1599 Miles

Number of One-Way Daily Passengers	Number of Daily Flights (By Aircraft Seating Capacity) 95	125	200	250	350	500
1-70	1	-	-	-	-	-
71-140	2	-	-	-	-	-
141-210	3	-	-	-	-	-
211-230	2	1	-	-	-	-
231-320	2	2	-	-	-	-
321-395	2	3	-	-	-	-
396-415	1	4	-	-	-	-
416-490	1	5	-	-	-	-
491-610	1	5	1	-	-	-
611-675	-	5	2	-	-	-
676-755	-	6	2	-	-	-
756-800	-	5	3	-	-	-
801-885	-	4	3	1	-	-
886-935	-	3	4	1	-	-
936-1065	-	3	5	1	-	-
1066-1145	-	2	5	2	-	-
1146-1235	-	3	5	2	-	-
1236-1340	-	3	4	2	1	-
1341-1480	-	3	5	2	1	-
1481-1585	-	3	4	2	2	-
1586-1670	-	2	4	3	2	-
1671-1760	-	1	4	4	2	-
1761-1815	-	-	5	4	2	-
1816-1960	-	-	6	4	2	-
1961-2140	-	-	6	5	2	-
2141-2320	-	-	6	6	2	-
2321-2605	-	-	5	7	3	-
2606-2780	-	-	5	6	3	1
2781-2890	-	-	4	6	4	1
2891-3105	-	-	3	6	4	2
3106-3355	-	-	3	6	5	2
3356-3610	-	-	3	6	6	2
3611-3860	-	-	3	6	7	2
3861-4075	-	-	2	6	7	3
4076-4325	-	-	2	6	8	3
4326-4685	-	-	2	6	8	4
4686-4795	-	-	1	6	9	4
4796-5010	-	-	-	6	9	5
5011-5185	-	-	-	5	9	6
5186-5440	-	-	-	5	10	6
5441-5690	-	-	-	3	11	7
5691-5940	-	-	-	1	12	8
5941-6115	-	-	-	-	12	9
6116-6475	-	-	-	-	12	10
6476-6815	-	-	-	-	12	11
↓ ↓ +340 Pax						↓ +1

FLIGHT SCHEDULING RULES - 1990

BWI & IAD: Over 1600 Miles

Number of One-Way Daily Passengers	Number of Daily Flights (By Aircraft Seating Capacity) 95	125	200	250	350	500
1-180	-	-	-	1	-	-
181-350	-	-	-	2	-	-
351-520	-	-	-	3	-	-
521-690	-	-	-	4	-	-
691-925	-	-	-	4	1	-
926-1165	-	-	-	4	2	-
1166-1395	-	-	-	4	3	-
1396-1625	-	-	-	4	4	-
1626-1790	-	-	-	3	4	1
1791-2015	-	-	-	3	5	1
2016-2245	-	-	-	3	6	1
2246-2410	-	-	-	2	6	2
2411-2640	-	-	-	2	7	2
2641-2870	-	-	-	2	8	2
2871-2970	-	-	-	2	7	3
2971-3200	-	-	-	2	8	3
3201-3265	-	-	-	1	9	3
3266-3365	-	-	-	1	8	4
3366-3430	-	-	-	-	9	4
3431-3760	-	-	-	-	9	5
+330 Pax						+1

FLIGHT SCHEDULING RULES - 1990

Commuter Markets

Number of One-Way Daily Passengers	Number of Daily Flights (By Aircraft Seating Capacity) 30	50
1-20	1	-
21-36	2	-
37-52	3	-
53-67	4	-
68-82	5	-
83-109	5	1
110-126	6	1
127-153	6	2
154-170	7	2
171-181	6	3
182-192	5	4
193-203	4	5
204-213	3	6
214-239	3	7
+26 Pax		+1

1990 FORECAST OF AIRCRAFT OPERATIONS BY TYPE OF AIRCRAFT

Aircraft Type By Number of Seats	Number of Daily Departures		
	DCA	BWI	IAD
95	20	73	80
125	305	49	60
175	0	13	16
250	0	13	32
350	0	2	5
500	0	0	0
30*	21	15	11
50*	40	6	2
ALL TYPES	386	171	206
	Average Seats Per Departure		
	111	119	138

*Commuter